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Assessment of climate change impact on watershed Hydrology

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Abstract
The hydrological parameters on water resources are of utmost importance for ensuring their appropriate management and utilization. The study was carried out to investigate the impact of climate change on watershed hydrology of Amaravathi river basin using SWAT model. The hydrological parameters *viz*., Precipitation, Soil moisture content, Surface Runoff, Evapo-Transpiration, and Groundwater Recharge was estimated spatially and temporally by water balance method using SWAT model. The Amaravathi river basin was divided into 15 sub basins based on the DEM and stream network. The monthly and annual hydrological parameters were simulated by SWAT for the period 1990 to 2017. The annual mean of soil moisture content was found to be 92.11 mm. The minimum and maximum soil water content was 65.00 mm and 110.73 mm occurred in 2013 and 1993. The maximum runoff of 703.24 mm occurred in the year 2013 and minimum runoff of 52.18 mm occurred in the year 1995. The average annual actual evapotranspiration varied between 477.81 mm (2008) to 303.78 mm (1995). The maximum and minimum groundwater recharge of 351.89 mm and 2.15 mm occurred in 2013 and 1995 with an average groundwater recharge of 105.43 mm. The decrease in recharge manifested itself as reduced discharge to streams and hence reduced stream flow. Hence the atmospheric moisture demand of the basin indicating the need of water from external / underground sources for successful crop production.

Keywords: Watershed, climate change, hydrology, SWAT

Introduction

Global environmental changes and demands for multiple use of increasing population make water management a difficult task especially in developing countries like India with exploding population. With the increase in population, reliable water is becoming a scarce commodity. Quantitative estimation of the hydrological parameters will be helpful in understanding potential water resource problems and making better planning decisions. Understanding the hydrological parameters on water resources is of utmost importance for ensuring their appropriate management and utilization. For this purpose, an appropriate hydrological model, the SWAT (Soil and Water Assessment Tool) is identified and this model is run with the meteorological parameters as input besides the watershed parameters. The main objective of this investigation is to study the impact of climate change on hydrological parameters of Amaravathi river basin, Tamil Nadu.

2. Methods and Materials

2.1 Study area

The Amaravathi basin lies between the latitudes 10° 06̕ 51” N and 11° 02’10”N and longitudes 77° 03̕ 24” E and 78° 13̕ 06” E. has a catchment area of 8544 km2 constituting four districts *viz.,* Coimbatore, Dindigul, Karur and Tirupur in Tamil Nadu. The basin is bounded by the Vaigai basin on the South, Noyyal basin on the North, Parambikulam Aliyar basin on the West and Ayyalur basin and Kadavur hills on the East. The river has major tributaries such as Kuthiraiyar, Shanmuganadhi, Nallathangalodai, Nanganjiar and Kodavanar from the South

2.2 Water balance using SWAT model

SWAT is a long term, physically based, continuous simulation watershed model. It has capabilities of simulating surface runoff, sediment yield and nutrient losses from small, medium and large watersheds. In conceptual basis SWAT divides a watershed into sub-basins. The use of sub-basins in a simulation is particularly beneficial when different areas of the watershed are dominated by land uses or soils dissimilar enough in properties to impact hydrology. By partitioning the watershed into sub-basins, the user is able to reference different areas of the watershed to one another spatially. Each sub-basin is connected through a stream channel and further divided in to Hydrologic Response Unit (HRU). HRU is a unique combination of a soil and a vegetation type in a sub basin, and SWAT simulates hydrology, vegetation growth, and management practices at the HRU level. Water, nutrients, sediment, and other pollutants from each HRU are summarized in each sub basin and then routed through the stream network to the watershed outlet.

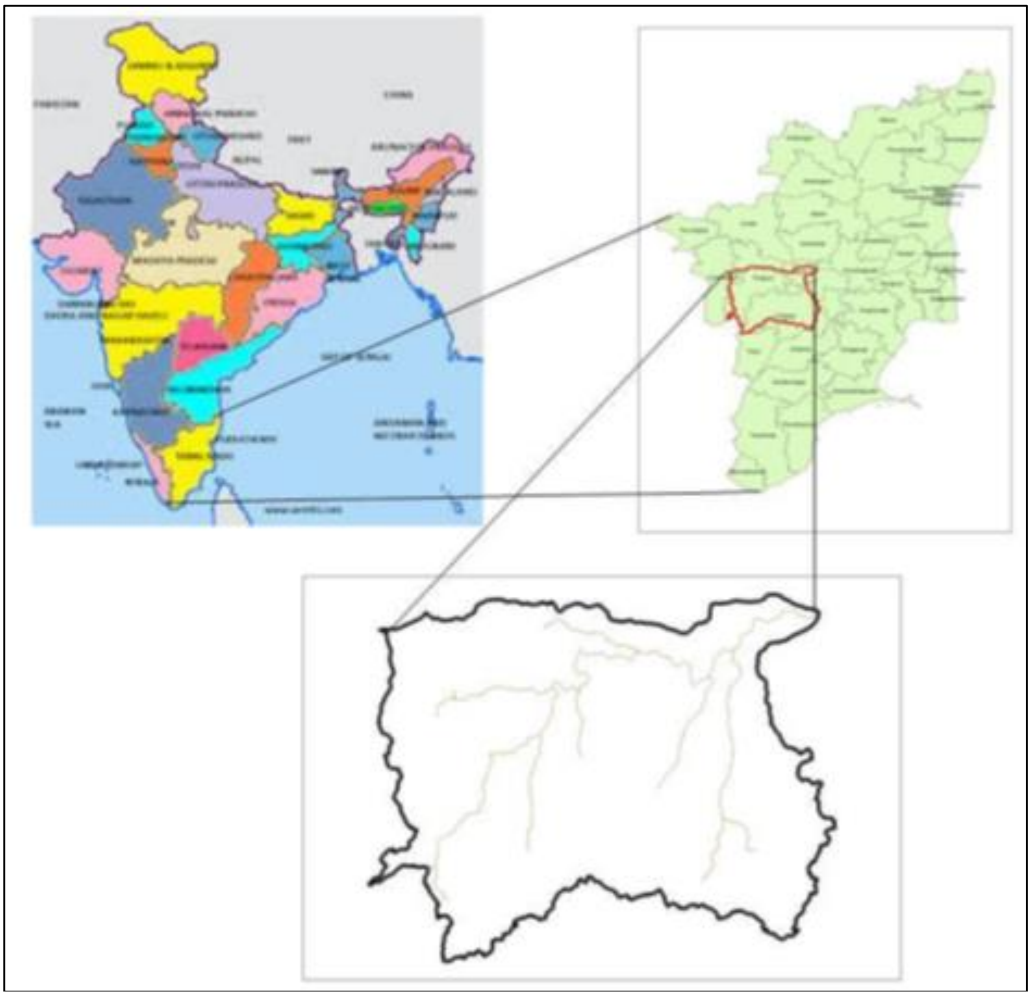

Fig 1: Location map of Amaravathi river basi**n**

2.3 Dataset needed for SWAT Model

The SWAT model requires a variety of detailed information describing the watershed *viz*., information on elevation, slope, soil, land use and climate. The source of the Digital elevation model (DEM) used in the study is 90 m resolution Shuttle Radar Topographic Mission (SRTM) (http://srtm.csi.cgiar.org/). Soil data from the FAO Digital Soil Map of the World (www.fao.org/geonetwork/srv/en/metadata*)* was used for defining the soils in the basin. The Land Use/Land Cover data at a spatial resolution of 56m obtained from the Department of remote sensing and GIS, TNAU.

Climatic data is one of the important components that drive the hydrologic model. The daily-observed gridded data of precipitation at 0.5^0 x 0.5^0 resolutions and maximum and minimum temperature at 1^0 by 1^0 resolutions obtained from the India Meteorological Department (IMD) was used for deriving the baseline (1981-2000) climate. Weather data on solar radiation, wind speed and relative humidity were generated using long-term statistics through the weather generator in built in the SWAT model.

2.4 Model setup

After preprocessing of all necessary data, set up for SWAT model has been prepared. Land use and soil map of the study area are imported to AVSWAT. After importing, the land use and soil themes were linked into SWAT database, Hydrologic Response Units (HRU's) distribution is determined by assigning threshold values to the land use and soil themes. The threshold value for land use and soil over sub-basin area were taken as 10 percentage respectively The HRU's are the portions of a sub watershed that possess unique land use, management and soil attributes. A total of 59 HRU's are created and that are distributed in 15 Sub basins.

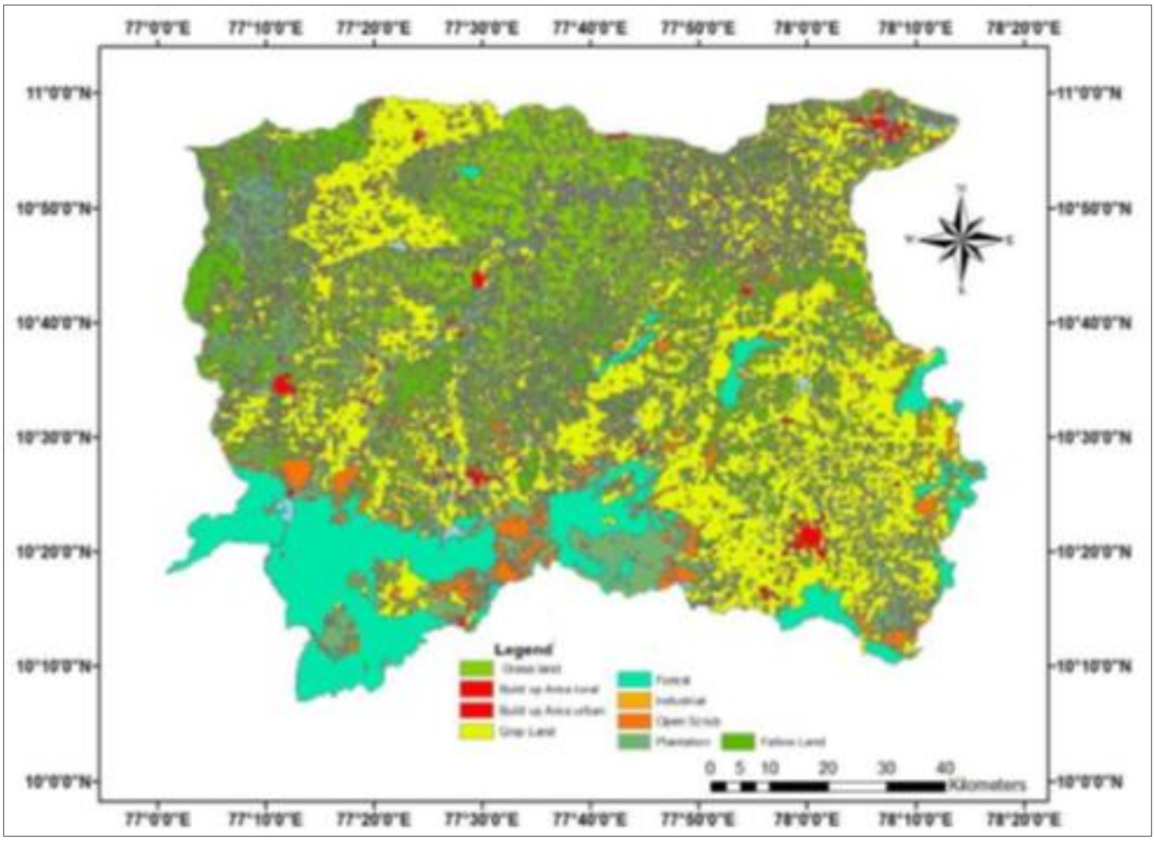

Fig 2: Land use map of Amaravathi river basin

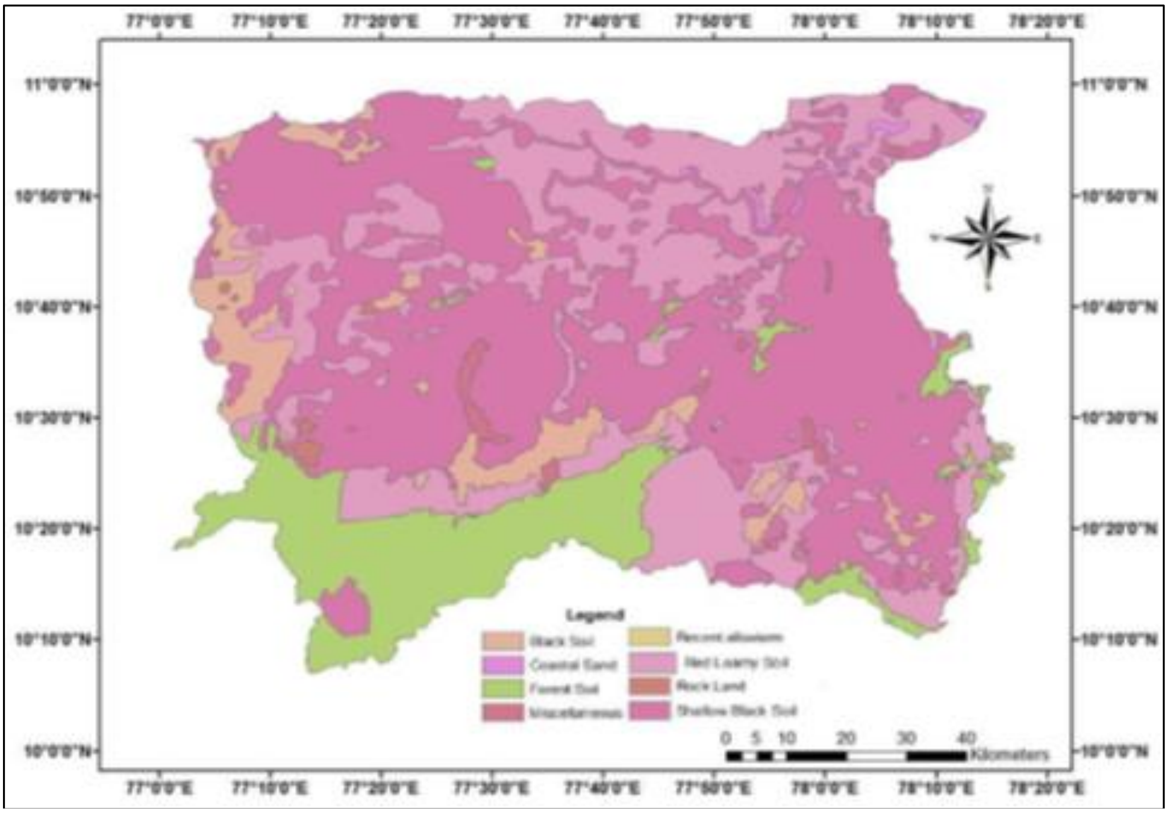

Fig 3: Soil map of Amaravathi river basin

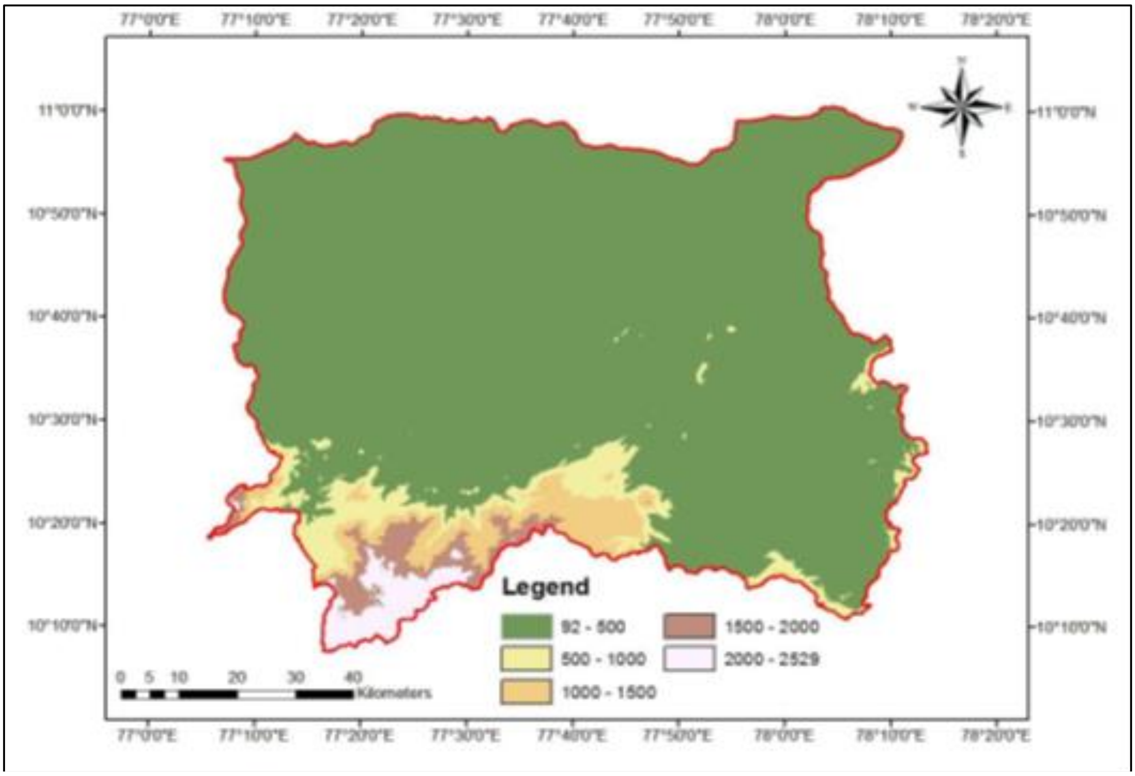

Fig 4: DEM map of Amaravathi river basin

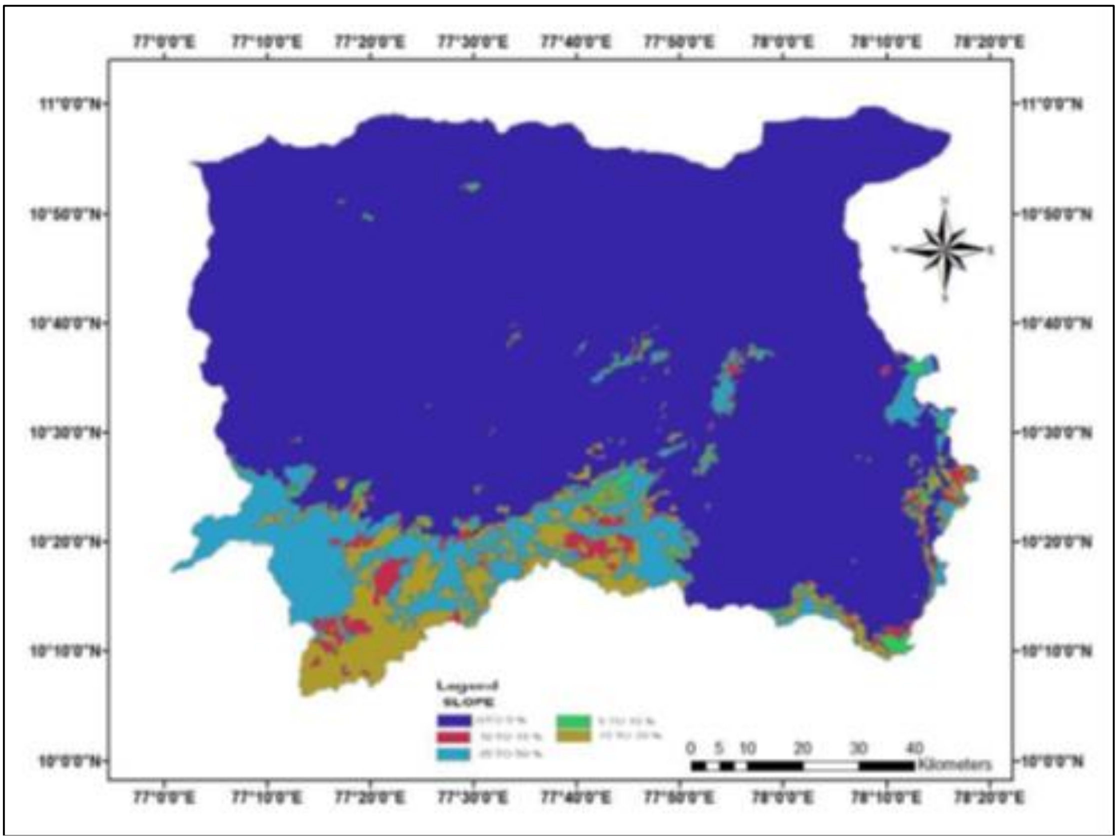

Fig 5: Slope map of Amaravathi river basin

3. Results and Discussions

The monthly hydrological parameters were simulated by SWAT for 28 years from 1990 to 2017. Amaravathi river basin receives major share of rainfall during North East monsoon season followed by South West monsoon season contributing 49 and 29 % to the annual rainfall respectively. The variation of rainfall is found in every month and the intensity of rainfall gradually increasing from January to May and decreasing trend noticed from June to August. The high intensity trends noticed in the month of October and November and these months received highest rainfall and reaches its maximum peak and start to decrease from the month of December and lowest in the month of January. The lowest rainfall recorded at Amaravathi river basin is 9.80 mm in the month of January and its maximum rainfall of 173.42 mm in the month of October.

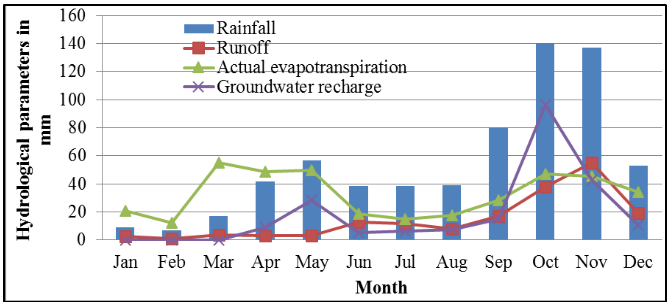

Fig 6: SWAT-simulated mean monthly water balance of the Amaravathi river basin

The period of increased actual evaporation rate corresponded to the period of summer, which usually brings a substantial amount of rainfall to the study area. Precipitation is higher than ET from May to December. The high groundwater recharge noticed in the month of October and November and these months received highest rainfall and reaches its maximum peak and start to decrease from the month of December and lowest in the month of January. The lowest groundwater recharge recorded at Amaravathi river basin is 0.01 mm in the month of January and its maximum rainfall is 96.19 mm in the month of October.

Spatial distribution basin wise changes in groundwater recharge for SWAT model are presented in Fig 7. The maximum and minimum groundwater recharge of 351.89 mm and 2.15 mm occurred in 2013 and 1995 with an average groundwater recharge of 105.43 mm Furthermore Crosbie *et al.*, (2009) found that even when there is no change in rainfall, the increase in temperature caused an increase in the vapour pressure deficit, which resulted in an increase in evapotranspiration and hence a decrease in recharge. The decrease in recharge manifested itself as reduced discharge to streams and hence reduced stream flow. This has very significant implications.

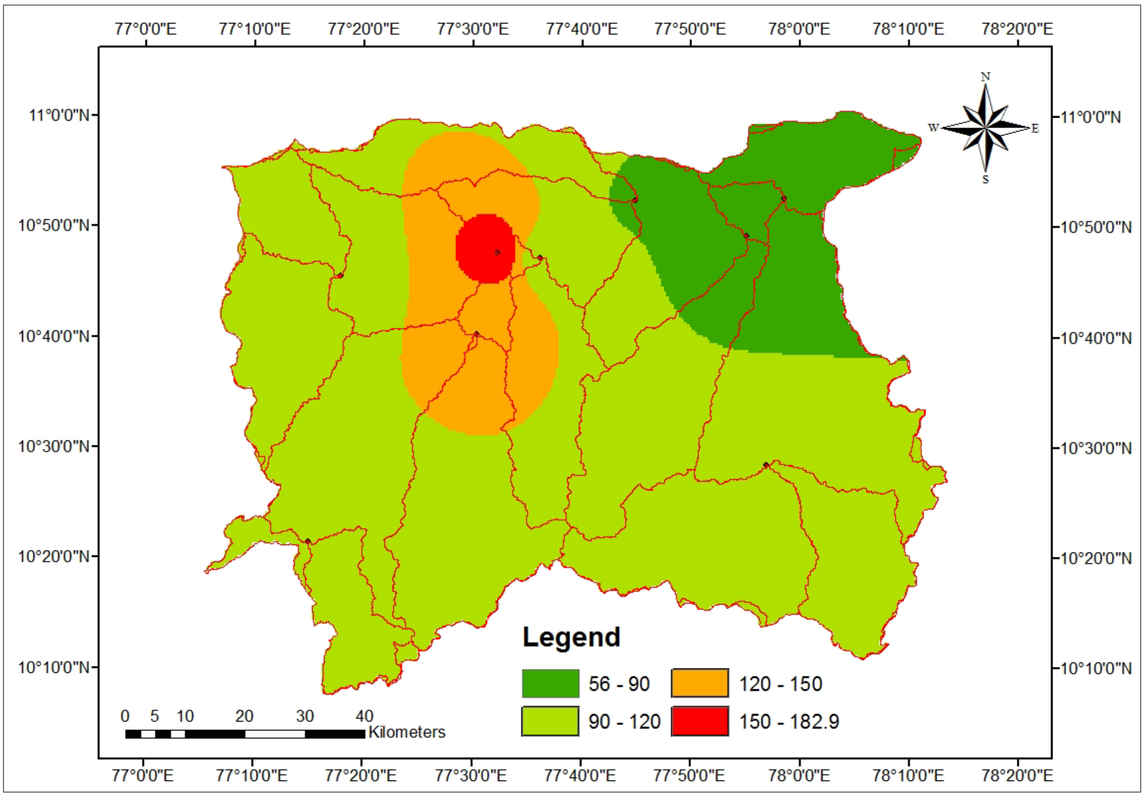

Fig 7: SWAT 267 Odeled spatial distribution of mean annual Groundwater recharge in the Amaravathi river basin

4. Summary and conclusion

The present study was taken up in Amaravathi river basin to study the impact of climate change on hydrology of river basin. The hydrological parameters *viz*., Precipitation, Soil moisture content, Surface Runoff, Evapo-Transpiration, and Groundwater Recharge was estimated spatially and temporally by water balance method using SWAT model. The Amaravathi river basin was divided into 15 sub basins based on the DEM and stream network. The minimum and maximum sizes of sub basins were 2.5 km2 and 35.86 km2 respectively. The highest groundwater recharge noticed in the month of October and November and these months received highest rainfall and reaches its maximum peak and start to decrease from the month of December and lowest in the month of January. The lowest groundwater recharge recorded at Amaravathi river basin is 0.01 mm in the month of January and its maximum rainfall is 96.19 mm in the month of October.

Hydrology of Amaravathi river basin would be greatly affected due to climate change. Rainfall and water yield are expected to increase in future as a result of changing climate. However, increase in intensity of extreme hydrologic events, crop water demand (ET) and decrease in soil water storage would pose serious challenges for sustainable crop production. Hence the atmospheric moisture demand of the basin indicating the need of water from external/underground sources for successful crop production.

5. References

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